Computational Fluid Dynamics Software

The invention relates to a method of providing customers with computational fluid dynamics modelling.

Computational fluid dynamics is the analysis and prediction of fluid flows and heat transfer using a computer model. It may be used to predict the flows of fluids through a heat exchanger, or into the cylinder head of a diesel engine, or through a valve or a mixing vessel for example. The first stage involves constructing a numerical model of the structure around or through which the flows are occurring, this being similar to the process of computer aided design. It is also necessary to provide to the numerical model the nature of the fluid flow as it enters the structure. The second stage is to a perform the computational fluid dynamics modelling for that structure and that input flow, this typically being performed in an iterative manner. The final stage is to convert the resulting flow information into an output form, for example a graphical representation showing the flow paths. Highly sophisticated software is now available for performing these activities, which enables a skilled user to model fluid flows and/or heat transfer in or around any conceivable structure. However the very sophistication that enables the software to cope with any fluid flow problem, makes it expensive and also complex; it would be desirable to provide a way of offering computational fluid dynamics modelling to customers that avoided their needing to learn how to use conventional Computational Fluid Dynamics software.

According to the present invention there is provided a method of supplying computational fluid dynamics modelling to customers, wherein the customer has a

network access device that includes client software, and is connected to a computer network, and the computational fluid dynamics software is provided on a server computer also connected to the network, the method involving:

(a) the customer connecting via the network to the server computer, using client software;

(b) the server computer providing a menu of several different categories of fluid flow problems, for display by the client software to the customer, and then the customer selecting a category, using the client software;

(c) the server computer requesting dimensional or other specific details relevant to the selected category of structure, for display by the client software to the customer, and then the customer providing those details, using the client software;

(d) the server computer performing the modelling of the structure as specified by the customer, and converting the results into an output form;

(e) the server computer notifying the customer that the results are available, and providing those results to the customer via the network.

A benefit of this method is that the customer does not require a very powerful computer and specialized software that can perform complex computational modelling, but only requires client software, for example a Web browser on only a moderately powerful computer. All three stages of the computational modelling (i.e. setting up the numerical model of the problem, running the fluid dynamics model, and generating an output form)

are performed by the server computer remotely. The output form of the results may be sent as computer files by email to the customer, or alternatively the customer may be notified by email of a Web address that provides access to the output form of the results stored on the server computer.

It will be appreciated that step (c) may need to be reiterated to provide sufficient detail. Preferably, as part of step (c), the customer is provided with the option of selecting a range for one or more parameters (such as pipe diameters), over which a different parameter (such as pressure drop) should be optimised. In this case step (d) requires the server computer to repeat the modelling many times, adjusting the values of the parameters within the specified ranges, in order to produce the optimum value of the parameter that is to be optimised.

Preferably the customer will be given the option of combining structures together, so that the output flow from one structure provides the input flow for the next, each structure being selected as in step (b) and its details specified as in step (c), before the modelling is performed as in step (d) on the combined structures.

The network linking the customer's network access device to the server computer may be a network within an individual company, or it may be the Internet. The network access device used by the customer may be a personal computer or a laptop computer, but may also be any device that provides access to the network, such as a mobile phone.

The invention will now be further and more particularly described, by way of example only, and with reference to the accompanying drawings in which:

Figure 1 shows a screen display for providing a customer with options;

Figure 2 shows a screen display requesting details from the customer; and

Figure 3 shows a screen display showing output results.

The invention enables any customer who has a device such as a personal computer which provides access to a network, and suitable client software such as a Web browser, to perform computational fluid dynamics simulations of a very wide range of different fluid flow problems. The customer requires no experience of computer aided design, nor of computational fluid dynamics; he needs only to be able to identify his problem. The invention will be described primarily from the perspective of the customer.

By using browser software the customer logs on via a network to a server computer that provides the modelling service. The server computer offers a wide range of categories of engineering problem that can be modelled, by presenting a screen display indicating those categories. Figure 1 shows an example of such a screen display, in which the customer is offered eight different categories: mixing vessels, ducts, static mixers, cyclones, furnaces, burners, combustors, or turbo-machinery. The customer selects the appropriate option by clicking on the appropriate part of the screen

display.

In practice a wider range of structures or categories might be offered. Furthermore, some or all of the categories might be subdivided; for example if the customer selects "static mixers", the server computer might respond with options such as: "tubular mixer with baffles", "fluidic vortex mixer", "intersecting ducts", which are the different types of static mixer.

Once the category of device has been sufficiently clearly specified, the customer is asked to provide more specific information. Again, this is done via the browser software, by presenting a screen display to the customer. Referring to figure 2, the screen display is shown that follows the customer selecting "static mixers", followed by "intersecting ducts". In this case the customer is asked for the diameters of the intersecting ducts at boxes 10 and 11, and for the angle at which they intersect at box 12. The customer will also be asked (using subsequent screen displays) to provide information on the flow rates through the two ducts, and the temperatures, etc. As indicated in figure 2, the customer may also be given the option of requesting that an output variable such as pressure drop, Delta P, at box 14 or temperature drop, Delta T, at box 15 should be optimised over a range of values of another parameter, such as the diameter of the side duct.

The server computer has access to templates for each of the potential categories of problem that the customer may select. The template indicates all the parameters whose values are required in order for the fluid dynamic modelling to be carried out. Once a category has been selected, the server computer presents in turn an

appropriate sequence of screen displays (such as that of figure 2) relevant to that particular category, so that all the parameter values required by the corresponding template are obtained. In some cases a specific numerical value may be required (e.g. the angle of intersection in degrees), while in other cases a range of numerical values (e.g. flow rates) may be required.

The customer then submits the problem by clicking on an appropriate box (as at box 18 in figure 2). The computer modelling of the flows through the specified structure may take several minutes, and possibly a few hours, depending on its complexity and on the nature of the request. For example if it is required to repeat the modelling many times, in order to find optimum values of a parameter such as pressure drop, Delta P, this will take longer than if it is merely required to predict the pressure drop for a specifically defined structure.

Once the server computer has completed the modelling process, the results are put into an output form, typically using graphical visualiser software. The results in this output form may then be sent to the customer, for example as a vrml file attached to an email; this file can then be viewed using the browser software. Alternatively the customer may be notified by email of the Web address of an output of the server computer, where his results are stored, and from where they may be downloaded using his client software.
Referring now to figure 3, this shows the resulting output display screen. In this case the results are represented both in numerical form, indicating numerical values of the calculated parameters in output boxes 20, and also graphically showing the nature of the flow as a picture 22. The picture 22 may be a still image, or a

moving image.

As a further option, the customer may be given the possibility of combining structures selected from the initial set of categories (as in figure 1) for example to mix fuel and air in a "static mixer", and then pass the mixture through a "burner".